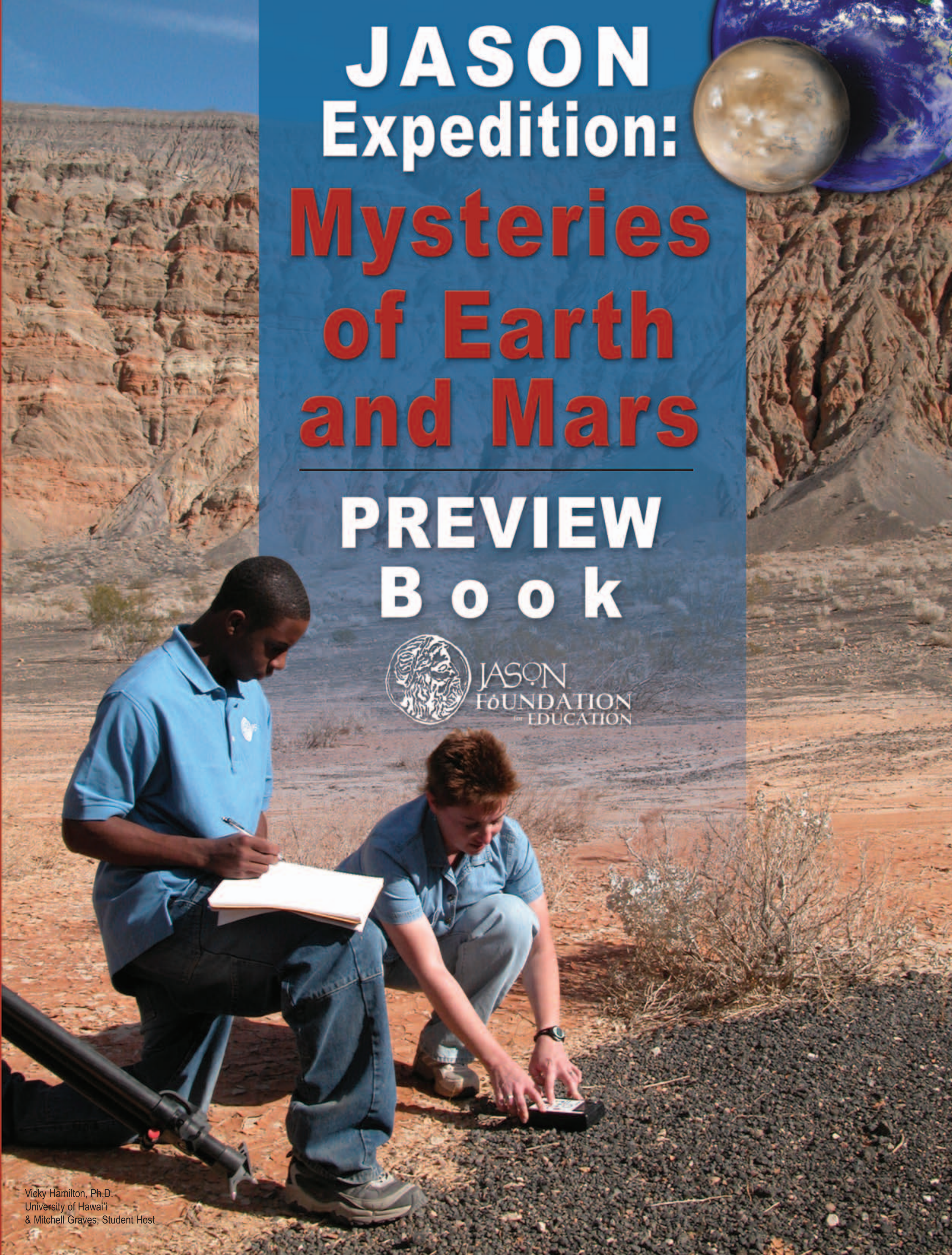
JASON Expedition:

Mysteries of Earth and Mars

PREVIEW Book

JASON Foundation for Education



Vicky Hamilton, Ph.D.
University of Hawai'i
& Mitchell Graves, Student Host

Join *JASON Expedition: Mysteries of Earth and Mars*

Explore the mysteries of Earth and Mars with JASON Chief Scientist, Dr. Robert Ballard, and a team of world-class scientists.

Use this Preview Book to examine the content-rich multimedia program developed by the JASON Foundation for Education.

Preview these exciting instructional components that have made JASON a leader in science exploration and inquiry.

- Host Researchers
- Program Contents
- Multimedia Components
- Team JASON Online
- Sample Research Article
- Sample Student Activity
- Sample Activity Masters
- Standards and Assessment
- Professional Development

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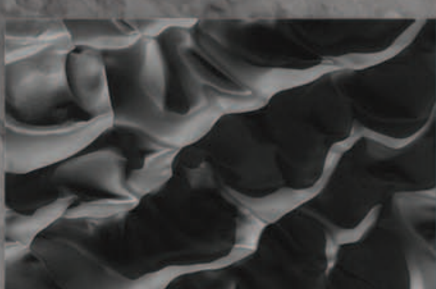


NASA/JPL/Malin Space Science Systems

Welcome to *JASON Expedition: Mysteries of Earth and Mars*

Here's a challenge: take a look at the two pictures on this page. One is a photograph of a landscape in southern Colorado. The other is a picture of the surface of Mars. Can you tell which is which?

For humans, Mars has always been a source of myths and mysteries, hopes and fears. But the more we learn about it, the more we find that Mars and Earth actually have a lot in common. Could it be that, by comparing Earth and Mars, we can discover important things about the nature and history of both planets?

In this JASON Expedition, students and teachers will have a once-in-a-lifetime opportunity to work with top scientists as we seek to uncover the Mysteries of Earth and Mars. We will tackle some of the big questions facing scientists today: What was the environment like on early Earth and Mars? How did life arise on Earth? And could there be life on Mars? This multimedia expedition offers middle-grade students a wide range of scientific investigation:

- Explore the principles of space travel with NASA engineers who helped design the latest generation of Mars rovers and orbiters.
- Compare and contrast the geology of Earth and Mars alongside NASA's chief scientist for Mars exploration and other planetary geologists.
- Come along with leading astrobiologists as they search for extreme lifeforms at Mars analogs–locations on Earth where environmental conditions resemble those on Mars.

Why an expedition to Mars? Why do we care about this desert-like planet? I'll tell you what I think. We care because we are all explorers at heart, and we have a strong natural desire to unlock the mysteries of our neighboring planet. With NASA launching one exciting mission to Mars after another, there has never been a better time to participate in Mars exploration. I hope you will join our team.

Dr. Robert Ballard
Founder and Chief Scientist
JASON Foundation for Education

Host Researchers

Unit 1: Physical Science

Kobie T. Boykins
Senior Mechanical Engineer
NASA Jet Propulsion Laboratory

Tracy D. Drain
Systems Engineer
NASA Jet Propulsion Laboratory

Unit 2: Earth & Space Science

Jim Garvin, Ph.D.
NASA Chief Scientist
NASA Headquarters

Vicky Hamilton, Ph.D.
Planetary Geologist
University of Hawai'i

Unit 3: Life Science

Jack D. Farmer, Ph.D.
Astrobiologist
Arizona State University

Linda Jahnke
Microbiologist
NASA Ames Research Center

Interview with Jim Garvin, Ph.D.

NASA Chief Scientist, NASA Headquarters

Research Focus: What can we learn from studying impact craters on Earth and Mars?

Why should students learn about our Solar System?

The Solar System is our real neighborhood. It provides context for us to understand our own planet and to seek answers to questions that have been with people forever. Where did we come from? Are we alone? Looking for our "roots" in the Solar System, whether on Mars, the Moon, new worlds such as Titan (Saturn's big moon), or elsewhere, is inspiring and requires creative thinking.

Where have you traveled for your work? What's the favorite place you've been to so far?

My travels have included multiple trips to Surtsey Island off the coast of Iceland. It's one of my favorite places. My license plates say "SURTSEY" here in Maryland, and people stop me to try to figure out what that means. I adore Iceland because of the primeval landscapes that evoke the processes we see on Mars.

When you are not working, what do you like to do for fun?

I have always been passionate about ice hockey. I played goaltender for 25 years in kid leagues, high school, college, club teams, and men's leagues. I have not played much in the past few years due to my job and young children at home, but I remain a hockey fanatic. I hope to get to Mars one day to skate on its wonderful and cold icecaps!

What advice would you give to students who are interested in studying science?

Science is not only about lots of challenging math problems and endless homework. It's really all about exploration. The hard work involved is just like the training that athletes go through to be able to participate in the Olympics or professional sports. With a little thinking and creativity, everyone who is interested can find a role and participate in science.

Program Contents

Introduction: Why Compare Earth and Mars?

Unit 1: Physical Science

Examines the physical properties of space science as well as the engineering challenges of robotic exploration. Topics include:

- Properties and changes of properties in matter: properties of water
- Motions and Forces: Newton's Laws, gravity
- Transfer of Energy: potential and kinetic energy
- Science and Technology: technological design

National Science Education Standards:

- B.1 Properties and Changes in Matter
- B.2 Motion and Forces
- B.3 Transfer of Energy
- D.1 Structure of the Earth System
- D.3 Earth in the Solar System
- E.1 Abilities of Technological Design

Unit 2: Earth and Space Science

Examines comparative planetology, the geological features and processes on Earth and Mars. Topics include:

- Physical Geology: landforms, rocks, minerals, and soil
- Geological Processes: tectonics, volcanism, cratering, erosion, and measuring geological time
- Electromagnetism: waves, infrared radiation, and spectroscopy
- Solar System: planets and meteors

National Science Education Standards:

- A.1 Abilities Necessary to do Scientific Inquiry
- A.2 Process of Scientific Inquiry
- B.1 Properties and Changes in Matter
- D.1 Structure of the Earth System
- D.2 Earth's History

Unit 3: Life Science

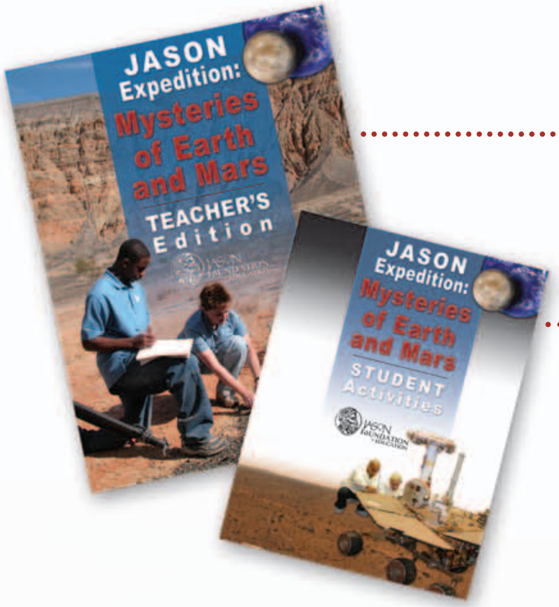
Examines requirements for life, astrobiology (the search for life throughout the solar system) and extremophiles (organisms adapted to extreme environments). Topics include:

- Requirements for Life: energy, nutrients, water
- Living Systems: structure and function in living systems, cells, microbes
- Diversity and Adaptation of Organisms: extreme environments, extremophiles
- Earth's History: fossils, biosignatures

National Science Education Standards:

- A Science as Inquiry
- B.1 Properties and Changes in Matter
- C.1 Structure and Function of Living Systems
- C.3 Regulation and Behavior
- C.4 Population and Ecosystems
- C.5 Diversity and Adaptations of Organisms
- D Earth and Space Science
- E Science and Technology
- G History and Nature of Science

Multimedia Components Complement Each Unit



Teacher's Edition

A versatile Teacher's Edition in wrap-around format with lesson cycle, teaching tips, links to all multi-media resources, and recommended literature selections. **See Pages 10-12 to learn more.**

Student Activities Book

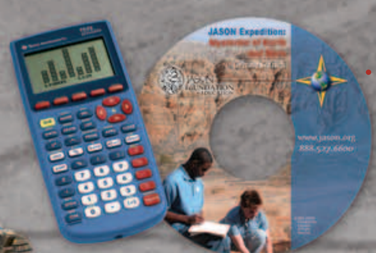
A Student Activities Book can function as either a blackline master book for the teacher, or as an Expedition workbook for each student. Book contains Articles and Student Activities as well as links to Team JASON Online. **See pages 8-9 to learn more.**

Introductory Video

The Introductory Video provides an overview of the Expedition, featuring JASON host researchers and student hosts exploring the physical properties of space science and space exploration, the search for life on Mars, and the geologic features and processes on Earth and Mars. Available in VHS and DVD format.

Team JASON Online with Digital Labs

Team JASON Online, a fantastic technology resource that includes a Teacher Center, interactive tools, activities, curriculum resources, and a worldwide community of scientists and JASON Expedition participants. **See pages 6-7 to learn more.**



Getting Started CD

The Getting Started CD is a multi-media tour of the Expedition components and all the resources available to you through JASON. It includes lesson demonstrations, additional activities and teacher resources with easy-to-follow instructions on how to utilize all the dynamic features of the Expedition. It also includes a tutorial, teacher resources, and activities using Texas Instruments graphing calculators and Vernier sensors.

Expedition Broadcast

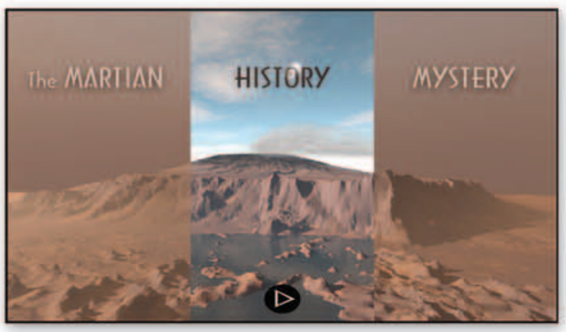
The hallmark of the JASON Expedition, the Expedition Broadcast actively engages students with the JASON host researchers, and student and teacher "Argonauts" as they explore Mars analogs—locations on Earth that approximate in some way the conditions found on Mars. A Program Guide and details of Expedition coverage are available through TJO.

Team JASON Online

Expedition Homepage

Welcome to the home page of **Team JASON Online**, your gateway to:

- **Teacher Center** - access assessment tools and classroom management tools
- **Digital Labs** - engage in interactive online activities and simulations
- **State Standards Correlations** - see how JASON materials match your state's education standards
- **Resources** - links to online components and more
- **Message Board** - communicate with your class and other participants
- **Chats** - interact with scientists and authors
- **My Journal** - provide online feedback to student journal entries
- **Unit Organizer** - view all multimedia resources for each unit
- **Expedition Gallery** - see photo collections from the Expedition broadcast.



Digital Lab: The Martian History Mystery

The **Digital Labs** are student-centered interactive online activities that model scientific exploration, allowing students to explore real data and have fun at the same time.

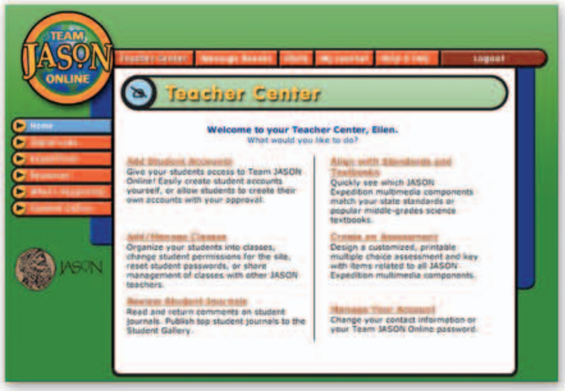
Unit 1 Digital Lab: Searching for Signs of Water
Students explore Gusev Crater with the Spirit Rover. They select a geologic feature, choose an instrument to look for evidence of water, and then compare their results to those of the research scientist. Like real scientists, the more instruments students use, the more confident they can be in their conclusions.

Unit 2 Digital Lab: The Martian History Mystery
Students describe the history of Martian geological activity. They estimate the relative ages of landforms such as impact craters, volcanoes, tectonic rift canyons, and wind-formed and water-formed features such as lakes, gullies, and river beds. Students then create a timeline to indicate when geological processes appeared to be most active and create a planet-wide activity map to reveal geographical patterns.

Unit 3 Digital Lab: Extreme Microbes
Students choose a particular habitat on Mars. Using microbes that live in extreme conditions on Earth (extremophiles) as examples, students then design their own extremophile that might survive on Mars. They then test their extremophile in the Martian habitat to see if it is properly adapted to live there.

In the **Teacher Center**, you can manage classes, review student journals, generate assessments, share classes with other JASON educators, and correlate your state's standards to the Expedition's curriculum.

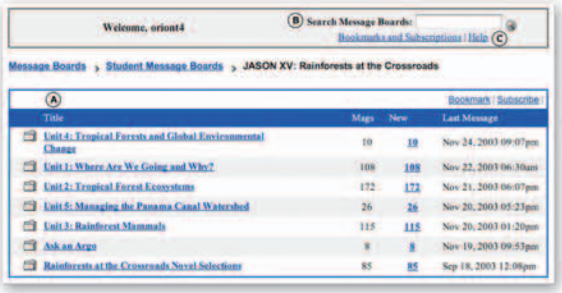
- Class management
- State and National Standards alignment
- Create an Assessment (Test Generator)
- Science textbook alignment



Teacher Center

The **Message Board** is a virtual worldwide community of students and teachers.

- Class Message Boards
- Teacher Message Boards
- Student Message Boards



Message Boards

Chats and Events provides teachers and students the opportunity to communicate with the host researchers and authors of literature selections. Chat events occur throughout the school year.

Chats

Linda Jahnke, NASA Ames Research Center
& Jeff Meng, Student Host

ARTICLE 2.2

Scientist Spotlight: Jim Garvin, Ph.D.

BIG QUESTION

How do impact craters form?

In your JASON Journal, record your ideas about how impact craters form.

Focus Questions

1. How do impact craters form on planets?
2. How do scientists study impact craters on Earth and Mars?
3. What do scientists learn by studying impact craters?

ARTICLE 2.2

Fun Fact

Impact craters sometimes explain important events in a planet's history. For example, scientists have linked Chicxulub (CHICK-shoo-loob) Crater in Mexico to a huge impact that occurred 65 million years ago. Many scientists believe that the impact caused the extinction of the dinosaurs and up to 50 percent of all living things on Earth! Chicxulub Crater is 180 km (112 mi) in diameter, and it was formed by an impactor about 10 km (6 mi) across.

Making an Impact

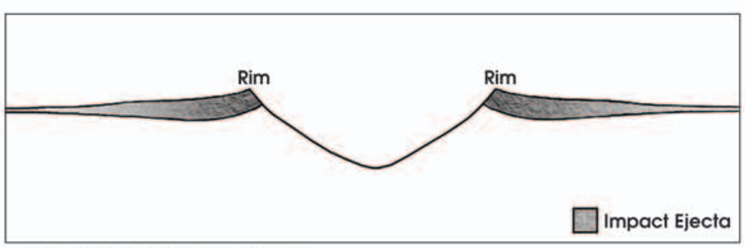
JASON host researcher Jim Garvin loves just about everything related to Mars. But he has a special love for **impact craters**, those fascinating circular pits that dot the planet. Impact craters form when rocks from space crash into a planet's surface. Impact craters on Mars can be smaller than a classroom in your school or larger than the state of Texas!

Because Garvin cannot travel to Mars, he needs the help of rovers and orbiters to study the craters there. Here on Earth, Garvin can visit impact craters himself. He has traveled to craters all over the world. He has even eaten his lunch inside a crater in Iceland!

1 How do impact craters form on planets?

Rocks from space crash into planets all of the time. But most of these rocks are too small and too slow-moving to make a crater. Sometimes, however, a big, fast-moving rock will hit a planet's surface with such force that it will explode into the ground. The explosion digs a pit, forming a crater. Space rocks that create craters are called **impactors**.

When an impactor hits a planet's surface, the explosion can release enough heat and energy to melt the entire impactor and some surrounding rocks. The explosion also sends dust and crushed rock fragments flying in all directions. These fragments, called **ejecta**, usually land around the impact crater in the shape of a ring. As it piles up in this ring, the ejecta forms a raised **rim** around the crater pit.



Side view of a simple impact crater.

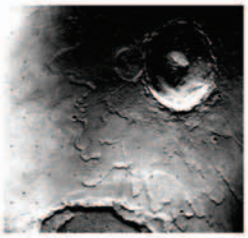
Images Top: Courtesy R. Bouchard, NASA

You can learn more about how craters help scientists study Martian geology by visiting the *Martian History Mystery* Digital Lab on Team JASON Online at **www.jason.org.** Not sure if you're registered on Team JASON Online? Check with your teacher.

2 How do scientists study impact craters on Earth and Mars?

On Earth, Jim Garvin has visited craters in places such as Arizona, Hawai'i, Germany, Iceland, and Kazakhstan (KAH-zak-stan). When he visits craters, Garvin makes various measurements and studies lots of rocks. He is especially interested in unusual rocks that are created during an impact. Some of these rocks form when Earth rocks melt and combine with pieces of an impactor. Garvin also studies Earth's impact craters from space. He designed an instrument that flew on the space shuttle and created three-dimensional maps of impact craters. These maps help Garvin study crater features that are hard to see from the ground.

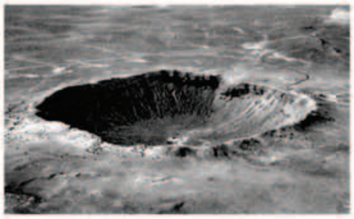
With the help of rovers and orbiters, Garvin has studied more than 10,000 Martian impact craters. The rovers Spirit and Opportunity explored several craters and their ejecta. Both rovers took pictures, analyzed rocks, and looked for signs of liquid water. Far above the surface, orbiter instruments have measured the size and shape of many more craters.



Simple impact crater on the Elysium Planitia of Mars.

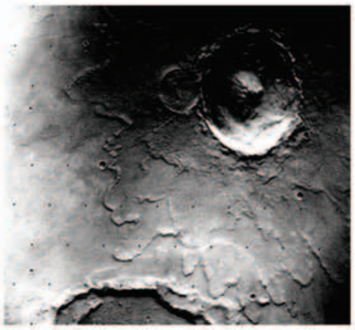
3 What do scientists learn by studying impact craters?

Impact craters can tell scientists a great deal about a planet. For example, impact craters can help scientists determine the age of a planet's surface. Surfaces that have a lot of craters are likely to be older than surfaces with only a few craters. Impact craters are also important because they uncover some of the rocks below a planet's surface. Jim Garvin likens craters to windows that let him see into the hidden parts of a planet's crust.



Meteor Crater in Arizona was formed when a 300,000-ton impactor crashed into the ground at 65,000 km per hour.

By studying impact craters on Mars, Garvin is uncovering important clues about the planet's geology. Some Martian impact craters have ejecta patterns that look like dried mud. Garvin believes that these "splosh" craters are evidence of frozen water below the surface of Mars. Their mud-like ejecta could have formed when the heat of impact melted underground ice and mixed it with soil and rocks. This discovery is important because water is essential to life as we know it. Impact craters may help scientists determine whether Mars was ever able to support life on its surface or underground.



Yuty Crater, a "splosh" crater on the Chryse Planitia of Mars.

Images Top: NASA/JPL/Malin Space Science Systems, Middle: Courtesy D. Roddy, USGS Astrogeology Research Program, Bottom: Courtesy D. Williams and J. Friedlander, NSSDC

Activity 2.2

Modeling Martian Craters

Learning Objectives

Students will be able to:

1 identify factors that influence the size and shape of impact craters.

2 explain how impact craters form.

3 describe advantages and disadvantages of using three-dimensional models to study impact craters.

Key Vocabulary

The boldfaced words in the Student Activity Book are defined in context. They are also defined in the Glossary.

Planning

ACTIVITY 2.2

- **Time**
  Setup: ½ hour
  Performance: three or four 45-minute class periods
- **Additional Materials**
  For each flour tray
  5-lb bag of flour
  1–2 garbage bags (8-gallon size or larger)
- **Complexity**
  High

Process Skills

- Formulating researchable question
- Stating hypothesis based on researchable question
- Listing materials for a fair test investigation
- Writing procedure for a fair test investigation
- Identifying independent and dependent variables
- Designing data tables or charts
- Entering data in data tables or charts
- Conducting student-designed inquiry investigation
- Making qualitative and quantitative observations
- Practicing metric measurement skills
- Interpreting data charts

ACTIVITY 2.2

Modeling Martian Craters

BIG QUESTION

How do impact craters form?

In your JASON Journal, record more ideas about how impact craters form.

JASON host researcher Jim Garvin uses many strategies to study impact craters on Earth and Mars. He compares craters on the two planets using numbers, pictures, and three-dimensional (3-D) models. In this activity, you will use various strategies to study craters. First you will investigate what factors influence the size and shape of craters. Then you will create a 3-D scale model of real impact craters on the surface of Mars.

Student Objectives

In this activity, you will

- investigate factors that influence the size and shape of impact craters.
- create a three-dimensional model of Martian impact craters.

Materials

For each student

- Activity Master 2.2A
- Activity Master 2.2B
- safety goggles
- apron

For each group

- flour tray (dishpan or tray filled about 5 cm deep with flour)
- 100 mL chocolate milk powder
- salt shaker *OR* beaker and strainer/flour sifter
- stick of modeling clay (¼ pound)
- 2 toothpicks
- meter stick
- metric ruler
- 4–6 sheets of newspaper
- balance (optional)

Procedure

Part 1: Observing Crater Formation

1. Set your flour tray on top of several pieces of newspaper.
2. Sprinkle or shake a thin layer of chocolate milk powder over the flour.
3. Form an impactor out of modeling clay.
4. Drop the impactor into the tray from a height of about 30 cm.
5. Use two toothpicks to gently lift the impactor from its crater.
6. Make observations of the crater using sketches, words, and numbers.

Part 2: Designing an Investigation to Explore Crater Formation

1. Brainstorm a list of different factors that might have affected the size or shape of the crater you made.
2. Choose one factor to investigate. The factor you choose should be something that you can change, such as the diameter of the impactor or the height from which you drop the impactor. This factor will be the **independent variable** in your investigation.
3. Think about how the size or shape of a crater might change in response to variations of your independent variable. Choose a factor to measure each time you vary your independent variable. The

Answers to Observations

1. Answers will vary. Some factors that could have influenced the size and shape of the craters are the mass of the impactor, the height from which the impactor was dropped (which is related to the speed of the impactor), the diameter of the impactor, the shape of the impactor, the angle of impact, and the degree to which the flour was packed down.
2. Answers will vary. The model craters are similar to craters on Mars because both have round shapes, ejecta, and raised rims. They are different because they are made of different materials; they are different sizes; and they are formed from impacts that involved different amounts of energy.
3. Answers will vary. Models that were initially unsuccessful might have had craters whose diameters or positions in the flour tray were not quite correct.

factor should be some measurable part of a crater, such as its diameter, the diameter of its ejecta, or its depth. This factor will be the **dependent variable** in your investigation.

4. Now write down a **research question** that will guide your investigation. Here's one possible format for your question: *How does changing [the independent variable] affect [the dependent variable]?*
5. Form a **hypothesis** that attempts to answer your research question. Your hypothesis should state *how* you think changing your independent variable will affect your dependent variable and *why* you think that.
6. List all of the **constants** for your investigation. These are the factors that you will keep the same throughout the entire investigation.
7. Design a series of at least three different variations for your investigation. You should change the independent variable for each variation and keep everything else the same.
8. Write a procedure for your investigation that describes each variation you will do and how you will record your results. Include a list of all the materials you will need for your investigation.

Part 3: Conducting an Investigation to Explore Crater Formation

1. Gather the materials you will need for your investigation.
2. Complete each variation in your investigation. For each variation, record your measurements for the independent variable and the dependent variable.
3. Describe your results using words, pictures, charts, and/or graphs, and determine whether or not your hypothesis was supported.
4. Share your findings with your class.

Part 4: Modeling Martian Impact Craters

1. In this part of the activity, you will create a 3-D scale model of the Martian impact craters shown on Master 2.2A. To begin, outline the rims of craters A through E.
2. Read the information on Master 2.2A, and use it to complete the table "Calculating the Diameters of the Craters on Mars."
3. Read the information on Master 2.2B, and use it to complete the table "Calculating the Expected Diameters of the Craters in Your Model."
4. Develop a plan for creating a model of each crater in your flour tray. Record your plan in the table "Modeling Martian Craters Plan: Trial 1."
5. Follow your plan to create a 3-D model of the Martian surface in your flour tray. Measure the actual crater diameters in your model and compare them to the diameters you expected.
6. Complete the table "Modeling Martian Craters Plan: Trial 2" to adjust your plan and make your model more accurate.

Observations

1. What factors influenced the size and shape of the craters you made?
2. How are the craters you made similar to and different from the craters on Mars?
3. Was your first try at creating a 3-D scale model of the Martian surface successful? Why or why not?

Conclusions

1. What are some advantages and disadvantages of using 3-D models to study craters on Mars?
2. How could you make a more realistic model of craters on Mars?
3. What have you learned to help answer the Big Question? In your JASON Journal, draft a final statement about how impact craters form.

Answers to Conclusions

1. One advantage of using 3-D models is that they can show the process of crater formation. They can also show depth-related features such as crater floors and raised rims, which can be hard to see in images. Some disadvantages of using 3-D models are that they might not show an exact representation of what is on the surface of Mars, and they might not show as many details as images.
2. A more realistic model of craters on Mars could be bigger, have more detail, be made of the same materials found on Mars, and be accurate in all dimensions.
3. An impact crater forms when an impactor smashes into the surface of a planet, creating a pit and sending material flying out in all directions. This material is called ejecta, and it usually lands around the crater in the shape of a ring. Some of the ejecta builds up around the edges of the crater and forms a raised rim. Large, heavy, and fast-moving impactors make bigger craters than small, lightweight, and slow-moving impactors.

- Analyzing data: looking for patterns
- Determining whether hypothesis was supported or not
- Stating findings from investigation
- Communicating scientific investigation to peers.

Preparation

1. Gather or purchase trays for the activity. Supply one tray for each group of 3–4 students.

   NOTE: Dishpans—the plastic kind you can buy at the grocery store—are an excellent choice because they are deep and sturdy. Lids to paper ream boxes work as well; be sure to tape over any holes at the corners of the lids. Trays should be at least 20 cm (about 8 in.) by 25 cm (about 10 in.) to fit a model with a scale factor of 2 cm/1 cm.
2. For easier cleanup, line each tray with one or two garbage bags.
3. Fill each tray about 5 cm (2 in.) deep with flour. Plan to use slightly less than one 5-lb bag of flour per tray.
4. If using strainers or sifters to sprinkle chocolate milk powder over the flour, supply each group with 100 mL (about ½ cup) powder in a beaker. If using salt shakers, pour 100 mL (about ½ cup) powder directly into the salt shaker for each group.
5. Gather and distribute the rest of the necessary materials for each group.
6. Before doing Part 1 as a class, demonstrate how to sprinkle the chocolate milk powder; emphasize that there should be a thin covering of powder over the entire surface of flour. Also demonstrate how to extract a clay impactor from its crater: poke two toothpicks at an angle into opposite sides of the clay and gently raise the impactor up.

Safety

Make sure students wear safety goggles at all times.

Flour can be slippery. Be sure to use lots of newspapers and to clean up spills quickly. Consider doing this activity outdoors.

Hands-on and Inquiry-based

Each of the twelve **Articles** included in the Expedition is followed by a student **Activity** that relates directly to the presentation. Hands-on and inquiry-based, all **Activities** include student learning objectives and correlate to national and state standards.

Students learn the scientific method by exploring and experimenting as scientists.

The **Activity Masters** accompany the **Activities** and provide how-to information, worksheets, and charts for observing and recording data.

Severe asthmatics might have problems with flour dust in the air during the activity. Consider using surgical masks to prevent inhalation of the dust.

For students with gluten allergies, substitute rice flour. For students with chocolate allergies, substitute strawberry milk powder or any juice drink powder.

Pre-Lab Discussion

Have students read "Article 2.2: Making an Impact" before doing this activity. Show students a map of Mars (if available) and ask them to think about why some craters might be bigger or smaller than other craters. Tell students that in this activity, they will design their own investigations to determine what factors influence the size and shape of impact craters. As a class, brainstorm different ways that scientists might study impact craters on Earth and Mars. Tell students that scientists make scale models to help them study landforms in three dimensions. Ask students to describe any models that they have seen or made. Explain that in this activity, students will be making their own 3-D scale models of Martian impact craters.

Inquiry Notes

Possible independent and dependent variables include:

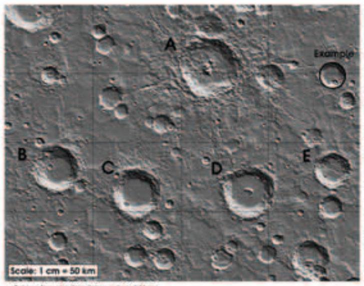
- Independent variables: diameter of impactor, height from which impactor is dropped, mass of impactor.
- Dependent variables: diameter of crater, circumference of crater, diameter of ejecta, depth of crater.

To vary the diameter of a clay impactor without changing its mass, students could flatten their clay balls into disks of various diameters. They could also form hollow balls of different diameters; form a hollow ball by making two clay bowls and joining them together. To vary the mass of an impactor without changing its diameter, students could form clay balls around items such as marbles, erasers, and paper.

Ask students to make observations about the crater they form in Part 1 of the activity to help them identify independent and dependent variables. Ask a question such as, "How do you think

ACTIVITY MASTER **2.2A**

Martian Craters



Craters from the Oxia Palus region of Mars.

Scale Factors

Scientists use scale factors to figure out how distances on images of Mars compare to distances on the actual surface of Mars. For the picture above, 1 cm on the image equals 50 km on the surface of Mars. The scale factor for the image is 50 km/1 cm (50 kilometers per centimeter). Multiply any centimeter distance on the image by this scale factor to find the actual kilometer distance on Mars.

Calculating the Diameters of the Craters on Mars

	Example	Crater A	Crater B	Crater C	Crater D	Crater E
Diameter in Image	0.9 cm					
Image Scale Factor	50 km/1 cm					
Diameter on Mars (Diameter in Image x Image Scale Factor)	0.9 cm x 50 km/1 cm = 45 km					

Teacher Tips

Flour will eventually darken from the chocolate milk powder. If the pow "shows up" on the surface, have students use a fresh layer of flour as a

On Master 2.2B, consider assigning a scale factor for younger students dents create gridlines in their flour tray using the tip of a pencil. This wi gauge the correct position for their craters.

Some students may succeed in making their model more quickly than Challenge these students to go back to Master 2.2A and add the next craters to their model.

ACTIVITY MASTER **2.2B**

Making a Model of Martian Craters

Choosing a Scale Factor

You will need to use a scale factor to change distances on the image in Master 2.2A to distances on your 3-D model. To make this easy to do, choose a scale factor such as 2 cm/1 cm or 3 cm/1 cm. If you choose a scale factor of 2 cm/1 cm, distances on your model will be twice as long as distances on the image. If you choose a scale factor of 3 cm/1 cm, distances on your model will be three times as long as distances on the image. Make sure your flour tray is big enough for the scale factor you select!

Calculating the Expected Diameters of the Craters in Your Model

	Example	Crater A	Crater B	Crater C	Crater D	Crater E
Diameter in Image	0.9 cm					
Model Scale Factor	2 cm/1 cm					
Expected Diameter in Model (Diameter in Image x Model Scale Factor)	0.9 cm x 2 cm/1 cm = 1.8 cm					

Modeling Martian Craters Plan: Trial 1

	Crater A	Crater B	Crater C	Crater D	Crater E
Expected Diameter of Crater in Model					
Diameter (or Mass) of Impactor					
Drop Height of Impactor					
Actual Diameter of Crater in Model					

Modeling Martian Craters Plan: Trial 2

	Crater A	Crater B	Crater C	Crater D	Crater E
Expected Diameter of Crater in Model					
Diameter (or Mass) of Impactor					
Drop Height of Impactor					
Actual Diameter of Crater in Model					

Aligning With Your State Standards

To align the content of Unit 2 to your state standards, go to **www.jason.org**, log onto Team JASON Online, click on **Teacher Center**, and then click on **Align with Standards and Textbooks**.

you could make a bigger or smaller crater?" to help students identify independent variables. Ask a question such as, "What numbers can you use to describe the crater you made?" to help students identify dependent variables.

If students need practice designing their own investigations, design a sample investigation as a class and then have students design different investigations in their groups. Or have the class brainstorm lists of independent and dependent variables and let students select from these lists to form their research questions.

Make sure students have a chance to share their results at the end of Part 3 of the activity. Each group should give a short oral description of its results. Groups could also design a poster or a PowerPoint presentation. After all groups have had a chance to present their findings, lead a discussion to help students summarize the results and prepare for Part 4 of the activity.

For Further Exploration

Have students research the approximate dimensions of your school, city, county, and/or state. Compare these local dimensions to the dimensions of features in the Martian craters image on Master 2.2A. Challenge students to find parts of the image that closely correspond to the dimensions of their local area.

Have students use binoculars to observe craters on the Moon. This can be done individually at night or as a class during the day. Have students research how craters on the Moon are similar to and different from craters on Mars.

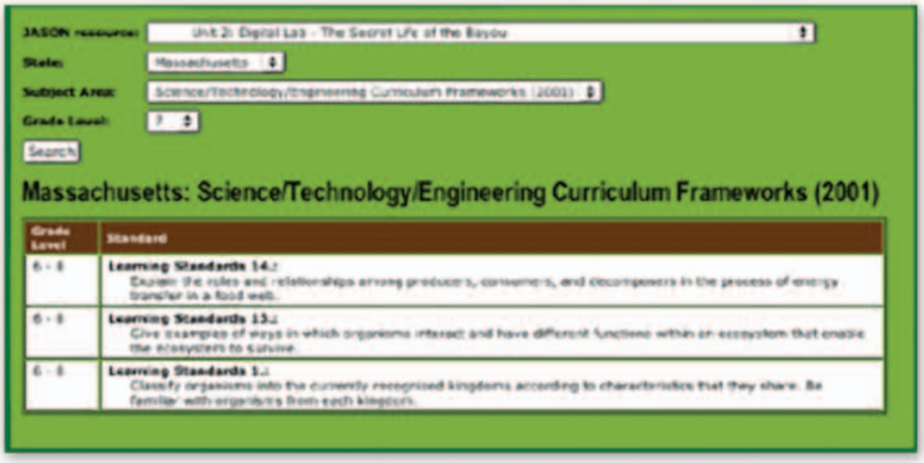
After students make their 3-D scale models, help them use an online or printed map to find the location of their model on Mars. The Martian craters image on Master 2.2A is at approximately 15 degrees N, 5 degrees W. Visit the **Resources** section of Team JASON Online for links to clickable atlases of Mars.

Visit the **Features** section of Team JASON Online to view a collection of 3-D Martian crater images. Make or purchase 3-D glasses to view the images.

Standards-based Curriculum

Aligning with Education Standards

JASON Expedition: Mysteries of Earth and Mars is truly a standards-based program. Curriculum materials are built on important state and national standards. The **JASON Standards Correlator** correlates the national standards as well as individual state standards to the content of each unit and to the content of each multimedia component.



Assessing Student Knowledge

All assessment items are standards-based and correlate to specific national and/or state standards.

- A set of multiple choice items for each unit appears in the Teacher's Edition
- A more extensive bank of items is available through Team JASON Online to support customized test generation
- **Show What You Know** provides an opportunity for student self-assessment at the end of each unit
- Authentic performance-based assessment in each curriculum unit provides alternative measures of student success

Assessment: Multiple Choice Questions

1. The size of an impact crater is affected by all of the following EXCEPT

   a. the diameter of the impactor
   b. the mass of the impactor
   c. the color of the impactor
   d. the speed of the impactor

   National Science Education Standards:
   - B.1 Properties and Changes in Matter
   - B.3 Transfer of Energy
   - D.1 Structure of the Earth System

2. Lucia wants to investigate whether the mass of an impactor affects the diameter of an impact crater. She drops three balls with different masses into a tray of flour. She drops all three balls from the same height, and she measures the diameter of each crater that forms.

   In this investigation, the diameter of an impact crater represents:

   a. the hypothesis
   b. the constant
   c. the independent variable
   d. the dependent variable

   National Science Education Standards:
   - A.1 Abilities Necessary to do Scientific Inquiry
   - B.3 Transfer of Energy

Professional Development with the JASON Academy

When teachers learn together, knowledge and skills advance by quantum leaps. JASON Academy brings that synergy to life in an array of onsite and online programs that help teachers gain confidence teaching core science and math content while earning NCLB highly-qualified status.

From tightly focused half-day workshops on science inquiry skills to week-long immersion experiences, JASON's powerful professional development programs have helped thousands of teachers become more knowledgeable and effective instructors.

JASON Academy Professional Development solutions include:

ONSITE

- **JASON Expedition:**

  Guided hands-on training by Certified JASON Trainers on the multimedia components of the ***JASON Expedition: Mysteries of Earth and Mars*** curriculum. (length varies)

- **JASON Conference:**

  High-energy conference built around the unveiling of ***JASON Expedition: Mysteries of Earth and Mars*** curriculum. CEUs are available. (2-3 days)

- **JASON Summer Institute:**

  An expedition site "immersion" experience for educators wanting an in-depth experience with the ***JASON Expedition: Mysteries of Earth and Mars*** theme. CEUs and graduate credit are available. (one week)

- **JASON Interactive Science:**

  Workshops on JASON themes and skills designed to enhance a teacher's understanding of key science content. (full day)

- **TI / Vernier Supplemental Activities:**

  Workshop featuring additional JASON activities plus TI-73 graphing calculators and Vernier probe training. Activity Book/CD included. (full day)

ONLINE

- **JASON Expedition:**

  Guided, synchronous course facilitated by Certified JASON Trainers on the multimedia components of the ***JASON Expedition: Mysteries of Earth and Mars*** curriculum. CEUs are available. (3 weeks)

- **Graduate Level Courses:**

  Content-rich facilitated online graduate level courses designed to help teachers meet the highly-qualified requirements of No Child Left Behind. CEUs and graduate credit available. (5 weeks)

  Courses are available in:
  - Science
  - Math
  - Pedagogy

For a complete listing of online courses and descriptions, visit us online at http://www.jason.org/academy.

JASON Coach

A custom professional development program can be designed for your educational setting by matching Certified JASON Trainer skills and knowledge with your JASON implementation needs. JASON Coaching services include ***JASON Expedition: Mysteries of Earth and Mars*** curriculum training plus a variety of additional services options.

Additional Expedition Enhancements

JASON Math Adventure: Algebraic Thinking and the Mysteries of Earth and Mars

This program for grades 6-8 is a multimedia kit of activities and resources that engages students in the mathematics used by scientists and researchers as they explore the similarities and differences of the physical and geological properties of Earth and Mars. The content is organized around six to eight activities consisting of real-life applications that use algebraic thinking as the core mathematics.

Students explore function, algebraic patterns, and multiple representations. Algebra topics such as integers, variables, coordinate geometry, graphical representation of data and functions, and linear relationships will be applied to science topics such as temperature, density, gravity, sea level, impact craters, and robotics.

Components include:

- Teacher's Guide with Student Activities
- Assessments consisting of multiple choice and performance assessment for each activity
- CD with interactive video segments, mini-labs, math tools, and print material
- Video/DVD connecting students to scientists and researchers through interviews and site tours (Mars analogs)
- Texas Instruments Graphing Calculator activities

TEXAS INSTRUMENTS

Carolina Biological Classroom Materials Kits

Carolina Biological Classroom Materials Kits are designed to supplement each ***JASON Expedition: Mysteries of Earth and Mars*** Teacher Pack. This custom kit provides unique hands-on materials for key exercises, classroom demonstrations, and learning stations. For 30 students.

CAROLINA
World-Class Support for Science & Math

Vernier Software & Technology JASON Probe Packages

Vernier and JASON have teamed up to create probe packs that are designed to complement JASON curricula and professional development offerings. The Starter Probe Package includes a Vernier LabPro interface, Stainless Steel Temperature Probe, TI Light Probe, Voltage Probe, and pH Sensor. The Deluxe Probe Package includes a Vernier LabPro interface, Stainless Steel Temperature Probe, TI Light Probe, Voltage Probe, pH Sensor, Salinity Sensor, Turbidity Sensor, Dissolved Oxygen Probe, and Motion Detector. The JASON probe packs can be used on a computer, Palm OS handhelds or with TI Graphing Calculators.

Vernier™

Curriculum Components

Teacher's Edition

Student Activities Book

Expedition Broadcast

TEAM JASON ONLINE

Team JASON Online

Getting Started CD

Introductory Video/DVD

Expedition Content Partners

National Aeronautics and Space Administration (NASA)

National Oceanic and Atmospheric Administration (NOAA)

Department of Education

Jet Propulsion Laboratory (JPL)

National Park Service

Arizona State University

University of Hawai'i

To learn about all of JASON's renowned science and math curricula and professional development, visit
http://www.jason.org

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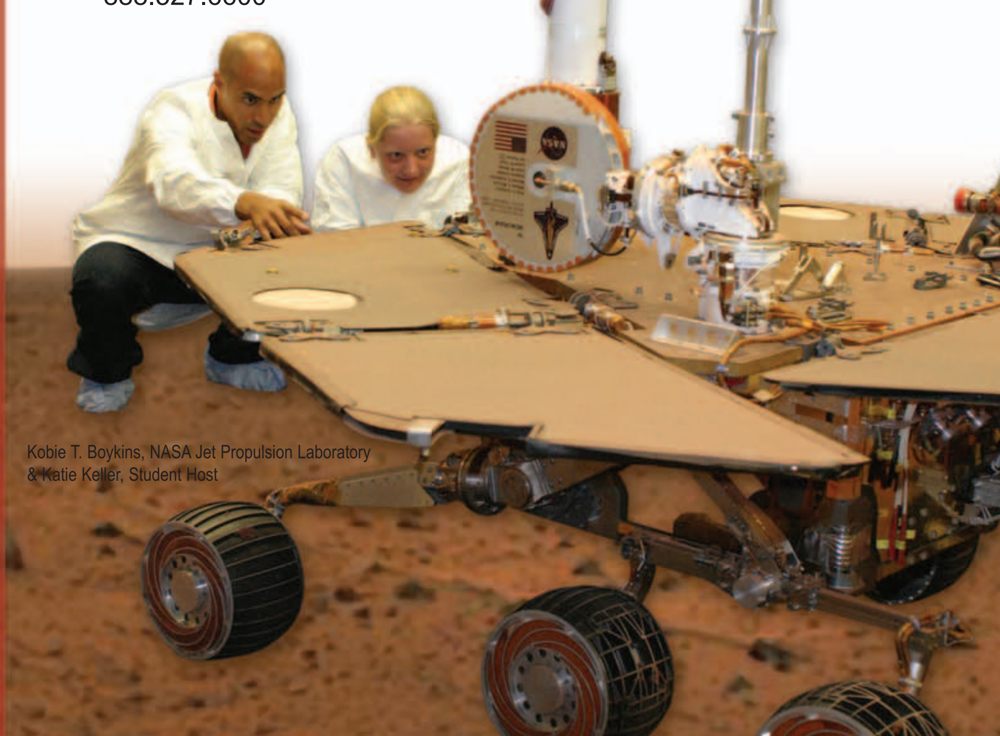

Kobie T. Boykins, NASA Jet Propulsion Laboratory & Katie Keller, Student Host